EFFECT OF PHOTOTHERAPY ON SERUM ELECTROLYTES IN NEONATES ≥35 WEEKS OF GESTATION WITH HYPERBILIRUBINEMIA

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ABSTRACT

Background: Neonatal hyperbilirubinemia is common (≈60% of term and 85% of preterm infants) and can lead to neurotoxicity or kernicterus if untreated. Phototherapy is the standard, effective treatment that converts unconjugated bilirubin into water-soluble isomers for excretion. However, phototherapy has been associated with electrolyte disturbances (hypocalcemia, hyponatremia, hyperkalemia) in some infants. We evaluated changes in serum sodium, potassium, calcium (ionized and total) and magnesium in neonates (≥35 weeks gestation) undergoing phototherapy.

Materials and Methods: We conducted a prospective observational study of 86 neonates ≥35 weeks gestation with unconjugated hyperbilirubinemia requiring phototherapy. Subjects were managed per AAP guidelines. Venous blood samples were obtained before phototherapy and after 48 hours. Serum sodium, potassium, total and ionized calcium, magnesium and total bilirubin were measured. Continuous variables are reported as mean ± SD. Paired t-tests compared pre- and post-therapy values; $p<0.05$ was considered significant.

Results: The cohort included 86 neonates (55.8% female) with mean age ≈5 days and mean birth weight ~2.72 kg. Table 1 shows that 34.9% were late-preterm (35–36+6 wk), 44.2% early-term, and 20.9% full-term; 24.4% were low birth weight (<2500 g). All had normal baseline electrolytes (Table 2). After 48 hours of phototherapy, mean total bilirubin fell significantly (14.95 ± 2.41 to 8.86 ± 2.03 mg/dL, $p<0.0001$). Serum sodium also declined significantly (139.36 ± 3.73 to 137.85 ± 3.91 mEq/L, $p<0.0001$), whereas changes in potassium (5.02 ± 0.80 to 4.98 ± 0.82 mEq/L, p=0.312), ionized calcium (1.10 ± 0.10 to 1.09 ± 0.10 mmol/L, p=0.689), total calcium (9.12 ± 0.48 to 9.10 ± 0.47 mg/dL, p=0.682) and magnesium (2.01 ± 0.65 to 1.99 ± 0.66 mEq/L, p=0.345) were not significant (Table 2). No neonate developed symptomatic hypocalcemia or severe hyponatremia. Subgroup analysis showed a greater mean sodium drop in low-birth-weight infants (–3.15 vs –1.02 mEq/L; p=0.016), but sex, gestational age and phototherapy type had no significant effects.

Conclusion: In this cohort of term neonates, phototherapy significantly lowered serum sodium but had minimal effects on potassium and calcium levels. These findings align with previous reports that phototherapy can cause mild hyponatremia and electrolyte shifts. We recommend routine monitoring of electrolytes during prolonged phototherapy, especially in high-risk or low-birth-weight infants.

Keywords: Neonatal Jaundice, Phototherapy, Serum Electrolytes, Hyponatremia, Hypocalcemia, Hyperbilirubinemia.

www.ajmrhs.com
eISSN: 2583-7761

Date of Received: 09-06-2026
Date Acceptance: 17-05-2026
Date of Publication: 16-07-2026

INTRODUCTION

Neonatal jaundice (unconjugated hyperbilirubinemia) is one of the most common conditions in newborns, affecting a majority of infants (≈60% of terms, 85% of preterms) in the first week of life[1]. Physiologic jaundice results from immature hepatic conjugation and high red-cell turnover. However, high serum unconjugated bilirubin can cross the blood-brain barrier and cause *bilirubin-induced neurologic dysfunction* (BIND) or kernicterus, leading to cerebral palsy, hearing loss and developmental delays. Prompt treatment is thus essential.

Phototherapy remains the cornerstone of management for neonatal hyperbilirubinemia[2]. Exposing neonates to blue-green light (peak ~460–490 nm) converts bilirubin into water-soluble photoisomers that can be excreted without conjugation. Effective phototherapy markedly reduces serum bilirubin, reducing the need for exchange transfusion and preventing neurotoxicity. The American Academy of Pediatrics (AAP) 2022 guidelines emphasize prompt phototherapy for infants ≥35 weeks at risk of severe hyperbilirubinemia.

Although generally safe, phototherapy has been associated with several adverse effects. Known side effects include hyperthermia, rash, increased stool output, bronze baby syndrome, and rarely retinal injury. More recently, attention has focused on phototherapy-induced electrolyte disturbances, particularly hypocalcemia and hyponatremia[3][4]. Several studies report up to 20–30% of neonates develop a drop in serum calcium during phototherapy[5][6]. The proposed mechanism for hypocalcemia involves phototherapy-mediated suppression of melatonin from the pineal gland, altering calcium homeostasis and increasing bone uptake of calcium. Hyponatremia (serum Na+ <135 mEq/L) has also been observed (reportedly ~11–17% of treated infants) and may reflect increased insensible water loss and sodium excretion during therapy[7][8]. Potassium and magnesium changes are less well documented, though some decline in potassium has been reported[9]. Overall, neonates under phototherapy appear at higher risk for "dyselectrolytemia," especially if preterm or low birth weight.

Despite these reports, the incidence and severity of electrolyte changes vary widely between studies. Many investigations include mixed term/preterm populations; data focused on mature (≥35 wk) infants in resource-limited settings are sparse. In India, where neonatal jaundice burden is high and phototherapy widely used, understanding electrolyte effects is critical for safe care[10]. Accordingly, this study prospectively evaluated serum sodium, potassium, calcium (ionized and total) and magnesium in term neonates undergoing phototherapy for hyperbilirubinemia, and identified factors influencing any changes.

MATERIALS AND METHODS

This prospective observational study was conducted in the newborn unit of a tertiary-care hospital. We enrolled all inborn and outborn neonates ≥35 weeks gestation admitted for management of indirect hyperbilirubinemia. Inclusion criteria were gestational age ≥35 weeks and indication for phototherapy per AAP guidelines. Exclusion criteria included hemolytic jaundice (Rh or ABO incompatibility), sepsis, major congenital anomalies, exchange transfusion, or maternal anticonvulsant use. Parental informed consent was obtained; the study was approved by the institutional ethics board.

All neonates received phototherapy according to standard protocols (blue LED lights, double-surface where feasible, infants undressed except diaper). Fluid intake and feeding were maintained per routine care; extra IV fluids were given if needed to compensate for any increased losses. Prior to phototherapy, venous blood was sampled for total serum bilirubin (TSB) and electrolytes. Phototherapy was then started and continued for at least 48 hours. A second blood sample was drawn at 48 hours after onset (or at termination of phototherapy) for repeat TSB and electrolytes. Serum sodium, potassium and total calcium were measured using an autoanalyzer, ionized calcium via ion-selective electrode, and magnesium via colorimetric assay.

Data collected included sex, birthweight, gestational age, mode of delivery and feeding status. Gestational age was categorized (35–36+6, 37–38+6, ≥39 weeks). Birth weight was classified as low (<2500g) or normal (≥2500g). The primary outcomes were mean changes in serum Na^+, K^+, Ca^{2+} and Mg^{2+} from baseline to 48h. Hypo- or hypernatremia/hypocalcemia were defined using local neonatal reference ranges.

Statistical analysis was performed using paired Student's t-tests for continuous variables and chi-square tests for categorical distributions. Data are reported as mean ± SD or n (%). P-values <0.05 were considered statistically significant. Results are presented in tables and figure legends provide key findings.

RESULTS

A total of 86 neonates met inclusion criteria. The demographics and baseline characteristics are summarized in Table 1. The mean gestational age was 37.2 ± 1.2 weeks. Most infants were delivered by cesarean section (76/86, 88.4%), and feeding methods were evenly distributed (39.5% exclusive breast-feeding, 40.7% formula, 19.8% mixed).

Table 1:Distribution of study neonates by gestational age and birth weight (n=86).

Category	n	%
Gestational Age		
35–36+6 weeks (late preterm)	30	34.9%

Category	n	%
37–38+6 weeks (early term)	38	44.2%
≥39 weeks (term)	18	20.9%
Birth Weight		
<2500 g (LBW)	21	24.4%
≥2500 g (NBW)	65	75.6%

Table 1 shows that 34.9% (30/86) were late-preterm (35–36+6 wk), 44.2% (38/86) early term (37–38+6 wk), and 20.9% (18/86) full-term (≥39 wk). Low birth weight (<2500g) accounted for 24.4% (21/86) of infants, with the remainder (75.6%) having normal birth weight.

Table 2:Mean (±SD) serum bilirubin and electrolytes before and after phototherapy (n=86).

Parameter	Pre-therapy (0 h)	Post-therapy (48 h)	P-value
Total Bilirubin (mg/dL)	14.95 ± 2.41	8.86 ± 2.03	<0.0001
Sodium (mEq/L)	139.36 ± 3.73	137.85 ± 3.91	0.00001
Potassium (mEq/L)	5.02 ± 0.80	4.98 ± 0.82	0.3125
Ionized Ca^{2+} (mmol/L)	1.10 ± 0.10	1.09 ± 0.10	0.689
Total Ca^{2+} (mg/dL)	9.12 ± 0.48	9.10 ± 0.47	0.682
Magnesium (mEq/L)	2.01 ± 0.65	1.99 ± 0.66	0.345

Table 2 compares the mean serum biochemistry before and after phototherapy. Baseline values were within normal limits (mean sodium 139.36 ± 3.73 mEq/L, potassium 5.02 ± 0.80 mEq/L, ionized Ca 1.10 ± 0.10 mmol/L, total Ca 9.12 ± 0.48 mg/dL, Mg 2.01 ± 0.65 mEq/L). After 48 hours of phototherapy, there was a significant decrease in serum sodium (139.36 to 137.85 mEq/L, mean difference –1.51; p<0.0001). Similarly, total bilirubin fell markedly (14.95 to 8.86 mg/dL, p<0.0001). Changes in serum potassium (5.02 to 4.98 mEq/L, p=0.312), ionized calcium (1.10 to 1.09 mmol/L, p=0.689), total calcium (9.12 to 9.10 mg/dL, p=0.682) and magnesium (2.01 to 1.99 mEq/L, p=0.345) were not statistically significant (Table 2). No cases of clinical hypocalcemia or severe hyponatremia occurred.

Figure 1: Comparison of Mean Serum Bilirubin and Electrolyte Levels Before and After Phototherapy

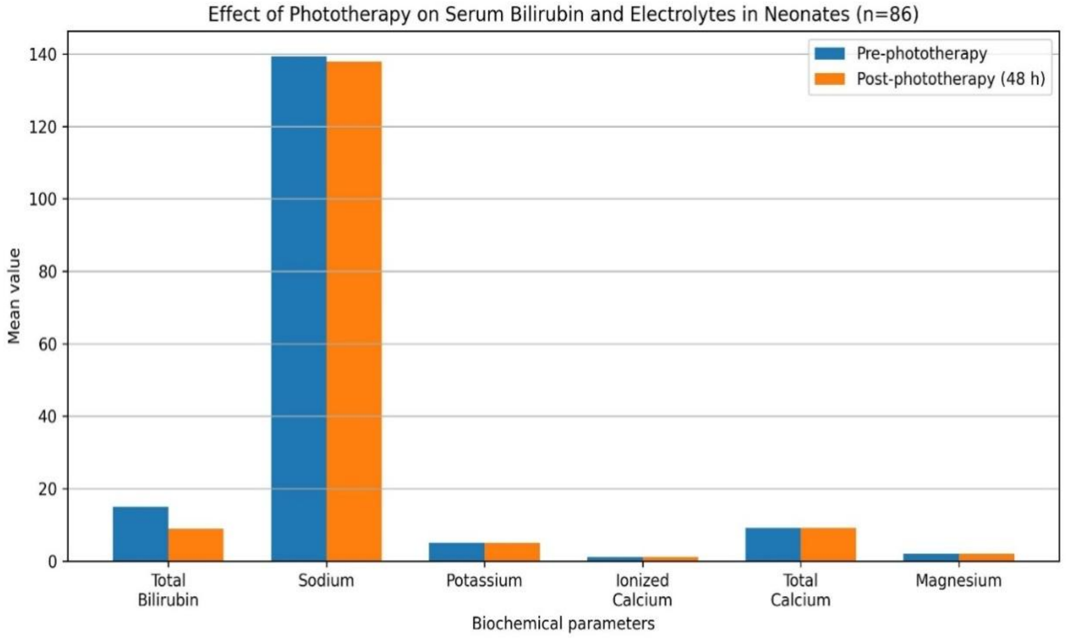

Figure 1 demonstrates the changes in mean serum bilirubin and electrolyte levels before and after 48 hours of phototherapy. A significant reduction was observed in serum bilirubin and sodium levels following phototherapy, whereas potassium, calcium (total and ionized), and magnesium levels showed only minimal, statistically insignificant changes.

Figure 2: Mean Sodium Decline by Birth Weight

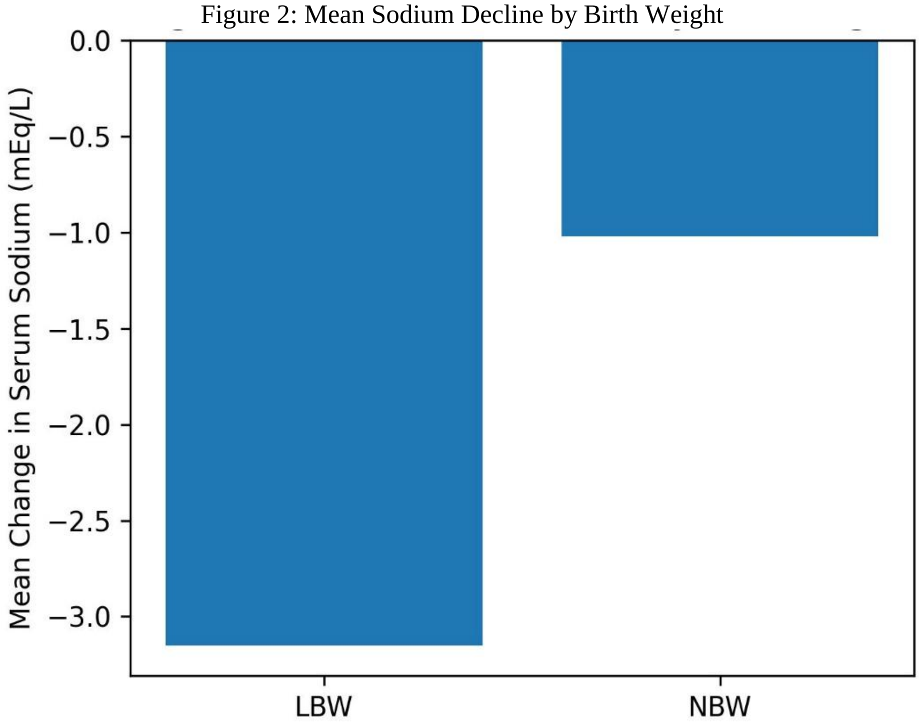

Figure 2 compares the mean decline in serum sodium between low birth weight (LBW) and normal birth weight (NBW) neonates after phototherapy. LBW neonates experienced a significantly greater reduction in serum sodium than NBW neonates, indicating that these infants may be more susceptible to phototherapy-associated electrolyte imbalance and require closer monitoring during treatment.

Subgroup analyses revealed that the mean decline in serum sodium was greater in low-birth-weight infants (mean ΔNa ≈ –3.15 ± 3.41 mEq/L) than in normal-weight infants (mean ΔNa ≈ –1.02 ± 2.74; $p=0.016$). Male infants tended to have a slightly larger Na drop than females, but this difference was not statistically significant ($p \approx 0.07$). There were no significant differences in electrolyte changes based on gestational age category, sex, mode of delivery, or phototherapy method (single vs double surface).

DISCUSSION

In this study of term neonates with hyperbilirubinemia, phototherapy produced a statistically significant decrease in serum sodium, while other electrolytes remained essentially unchanged. A reduction in serum sodium during phototherapy has been reported by others, attributed to increased insensible water loss and dilutional effects. Our finding of a ~1.5–mEq/L sodium drop ($p<0.0001$) is consistent with prior reports of mild hyponatremia in ~10–20% of infants[3]. For example, Korde et al. found significant mean declines in Na, K and Ca after phototherapy ($p<0.001$), and Monika et al. noted 16.7% incidence of hyponatremia in term neonates under phototherapy. Curtis et al. also emphasized that phototherapy can disrupt water and sodium balance. In our cohort, no neonate developed severe hyponatremia; the declines were modest and asymptomatic, likely reflecting the modest average fall reported here. Notably, low-birth-weight infants in our study had a larger mean sodium drop, echoing observations that smaller, less mature neonates have greater vulnerability to fluid and electrolyte shifts[11].

Serum calcium (total and ionized) did not change significantly in our infants. Previous studies have documented phototherapy-related hypocalcemia in 10–60% of treated neonates[12][13]. The proposed mechanism involves phototherapy-induced suppression of melatonin, leading to increased calcium uptake by bone. However, the clinical impact is variable. In our study, mean total Ca remained essentially the same (9.12 to 9.10 mg/dL; $p=0.682$). This aligns with some prior reports showing minimal average calcium decline, despite a minority of infants developing subclinical hypocalcemia. We monitored for symptomatic hypocalcemia (twitching, apnea, ECG changes) and found none. Thus, our results suggest that routine phototherapy (primarily LED-based) has limited impact on serum calcium in term infants. Potassium changes were also negligible, consistent with other reports that phototherapy does not generally cause clinically significant hypokalemia[8].

Phototherapy's impact on electrolytes likely reflects multiple factors. Increased skin blood flow and body temperature during phototherapy can elevate insensible water losses, diluting plasma sodium[4]. At the same time, neonates under phototherapy may have increased renal electrolyte excretion. Our findings of a significant Na drop but stable K and Ca suggest that modest dilution/hyponatremia occurs, whereas calcium homeostasis is maintained in most infants. The fact that we did not observe a large decline in total or ionized calcium may be due to adequate paracellular regulation or nutritional calcium supply.

It is worth noting the strengths of our study. We focused exclusively on neonates ≥35 weeks, reflecting the population most treated under current guidelines. Our sample was reasonably large for a single center (n=86) and data were collected prospectively. Limitations include lack of a control group without phototherapy (ethically difficult since all had clinical jaundice) and reliance on a single follow-up time-point (48h). We did not measure changes at earlier intervals (e.g. 24h) which might detect transient changes. Fluid intake was not strictly protocolized beyond standard care, so inter-individual variability in hydration could have influenced results. Finally, this was a single-center study; environmental factors (humidity, phototherapy power) may affect generalizability.

CONCLUSION

In summary, phototherapy in late-preterm and term neonates produces a modest but statistically significant decline in serum sodium, with no appreciable change in potassium or calcium levels. These observations are consistent with other reports that phototherapy is associated with mild hyponatremia and electrolyte shifts. Clinicians should be aware of this potential effect, especially during prolonged therapy or in at-risk infants. We recommend that electrolytes be monitored during intensive phototherapy, and that adequate hydration be maintained (to offset insensible losses). Overall, phototherapy remains a safe and effective intervention for neonatal jaundice, and its benefits far outweigh the small risks of electrolyte imbalance in term infants.

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How to cite this article: Dr. Prema Shalini, Dr. Gurpreet singh Chhabra, Dr. Gursharan Singh Narang, EFFECT OF PHOTOTHERAPY ON SERUM ELECTROLYTES IN NEONATES ≥35 WEEKS OF GESTATION WITH HYPERBILIRUBINEMIA, Asian J. Med. Res. Health Sci., 2026; 4 (2):2228-2233.

Source of Support: Nil, Conflicts of Interest: None declared.